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THE PSYCHOLOGICAL ATTRIBUTES OF ULTRAMARATHON RUNNERS AND FACTORS WHICH LIMIT ENDURANCE

U S ARMY RESEARCH INSTITUTE
OF
ENVIRONMENTAL MEDICINE
Natick, Massachusetts

APRIL 1987

UNITED STATES ARMY
MEDICAL RESEARCH & DEVELOPMENT COMMAND

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AD

TECHNICAL REPORT

NO. T21-87

THE PSYCHOLOGICAL ATTRIBUTES OF ULTRAMARATHON RUNNERS AND FACTORS WHICH LIMIT ENDURANCE

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Psychological and training characteristics of 44 ultramarathoners competing in a 50-mile trail race were studied. These psychological and training variables were used to distinguish differences between survivors and casualties in the race and to predict race time. In addition, mood changes and runners physical symptoms were examined to assess changes from pre to post-race. Results show a mood profile and self-motivation scores similar to other athletic populations. Mood profile changed from pre to post race and training pace was found to be a highly significant factor in predicting finish time.

INTRODUCTION

The tactical importance of a soldier's ability to move as quickly as possible over a variety of terrain is critical in certain military maneuvers. Air assault, light infantry and special forces may require the soldier to navigate cross country for a sustained period of 72 hours or more. The physical and psychological demands of these types of military operations are similar to competitive endurance events such as 50 and 100 mile trail runs. These trail racing ultramarathoners, like dismounted soldiers, must often traverse distances up to 100 miles over wet and rocky terrain in temperatures ranging from below freezing to above 100 degrees fahrenheit. Reports of sprains, lacerations, excessive weight loss and hypothermia are common during races as are complaints of hallucinations and paranoia. The importance that psychological factors play in this type of endeavor cannot be underestimated. Since the ultramarathoner and dismounted soldier must persevere at a physically demanding task for an extended period of time, his psychological state can be expected to have a profound impact on endurance performance.

Previous research over the past decade has thoroughly demonstrated changes in mood states as a function of physical exercise (Folkins, 1976; Folkins and Sime, 1981; Dishman, 1985; Morgan, 1985). Most studies to date have assessed mood states before and after acute physical exercise of one to three hours

duration or before and after chronic exercise programs lasting 6-20 weeks. Typically, improved affective states and antidepressant effects accompany both acute and chronic physical activity (see review by Dishman, 1985). Acute exercise of vigorous intensities has been shown to reduce state anxiety and depression (Markoff et al. 1982; Bahrke and Morgan, 1978; Morgan et al. 1980; Berger and Owen, 1983). Moreover, exercise-induced euphoria, most typically reported in runners and commonly known as "runner's high", may represent another form of mood alteration. Most of the psychological and physiological studies of acute exercise have focused on running durations of anywhere from 30 minutes on a treadmill to 3 hours for a marathon. Much less well known, however, are mood changes associated with a single sustained vigorous exercise of ten hours or more in duration such as the ultramarathon. Costill (1972) reported that the average marathoner expends approximately 2,400 kcal while Thompson et al (1982) report that 50-mile ultramarathoners expend from 5,937 kcal for nonelite runners to 6,065 kcal for elite runners. Where there are differences in the physiologic demands of these endurance events there may also be differences in mood states. In addition, research investigating the subjective symptomatology associated with ultramarathon performance is lacking.

Successful performance in endurance events such as the ultramarathon may be associated with changes in subjective symptoms and mood states during competition. Previous research by Morgan and

Pollock (1977) suggest that successful endurance performance is governed by one's physical capacity and the willingness to tolerate discomfort associated with hard physical work. The decision to stop, maintain pace, or accelerate pace while performing an endurance event such as the marathon is a cognitive process (Morgan, Horstman, Cymerman & Stokes, 1983) characterized by an integration of parameters such as ventilatory minute volume, catecholamine production, muscle lactate, cardiac frequency, and state of physical fitness (Pandolf, 1978). The successful ultramarathon runner must persevere in an event involving prolonged strenuous exercise at an average of 72% to 84% of VO2 max (Thompson et al., 1982) often under environmentally taxing conditions (i.e., heat, altitude, rugged footing, etc.).

Published studies on subjective reports of physical symptoms or mood states associated with ultramarathon competitions are practically non-existent. One of the few studies (Joesting, 1981) found no differences in depression, anxiety, or hostility before, during, and after running in a 50-mile race. Since the author was the only test subject, however, there is skepticism with respect to these results.

Previous studies have investigated factors related to marathon performance time. Slovic (1977) reported that the best predictors of marathon time, in two male samples (R = .89, .87), were combinations of quantitative (total mileage and length of longest training run) and qualitative variables (fastest 5- and 10-mile

times). Slovic also reported equations without 5- and 10-mile times which were less accurate (R = .72, .74) and based on total mileage, longest run and marathon completion, age, and ponderal index (a measure based on height and weight to characterize leanness). Mc Kelvie et. al. (1985) also identified variables to predict marathon time. The overall prediction was accurate (R = .89), with training pace the most important factor in combination with 10-km time, miles per week run, previous marathons completed, days lost through injury or illness, and a personality characteristic for repression-sensitization.

The purpose of the present study was to examine psychological characteristics associated with performance in the ultramarathon. Specifically under study were 1) mood states and physical symptoms which change as a function of the sustained acute strenuous exercise of a 50 mile ultramarathon, 2) demographic factors, moods and physical symptoms which differentiate finishers from non-finishers, 3) goals for participation along with motivation level, and 4) factors which best predict ultramarathon (50-mile) time.

METHOD

Subjects

The subjects consisted of 44 registered entrants (42 males and 2 females) of the Massanutten Mountain Massacre 50-mile trail run who volunteered to participate in the study. All subjects were

instructed to read and sign a volunteer agreement of informed consent.

Apparatus

A Performance Assessment Battery was administered pre and post run. The battery consisted of a Demographics Questionnaire, a Self-Motivation Inventory (SMI), an Environmental Symptoms Questionnaire (ESQ), Profile of Mood States (POMS), and a test of Trait Anxiety (FORM X-2). The Demographics Questionnaire was administered to ascertain basic demographic variables such as height, weight, age, and background running and training information. The ESQ consisted of a 41 item inventory of symptom states and was administered to assess psychological perceptions of physiologically based symptoms experienced pre and post run. The POMS (McNair, Lorr & Druppleman, 1981) consisted of 65 mood items administered to assess mood state changes in pre and post-run conditions. The SMI (Dishman, Ickles & Morgan, 1980) was composed of a 40 item inventory administered to assess motivation towards training. The FORM X-2 questionnaire consisted of a 20 item test measuring trait anxiety (Spielberger, Gorsuch & Lushene, 1970).

Procedure

All registered runners in the Massanutten Mountain Massacre Trail Run were requested to complete the Performance Assessement Battery. Of the sixty-one registered runners, forty-four volunteered to participate as subjects. All subjects were asked to complete the battery which was administered ten hours prior to the start of the run. In addition, subjects were informed that they would be requested to complete the ESQ and POMS upon terminating the run. During the run, data collectors waited for subjects to reach various checkpoints and administered post-run questionnaires to any subject that withdrew or was removed from the race. Runners were pulled from the race at the 33-mile mark if they had not completed that distance by eight hours and removed at the 44-mile mark if not completed by ten hours. The time constraint was necessary to ensure that all runners completed the race in daylight. The race course terrain ranged from soft muddy footing to rugged rocky covering. Elevation varied from a low of 700 feet to a high of 2650 feet. A net gain and loss of 7000 feet was achieved. The average daytime temperature was 60 degrees fahrenheit with a range of 54 to 63 degrees. Upon completion of the race, voluntary withdrawl, or administrative or medical removal, a post-run questionnaire was administered. Any subject who withdrew from the race and was not administered a questionnaire at one of the checkpoints was administered the post-run questionnaire at the finish area.

RESULTS

The 50-mile trail run was completed by 22 of the 61 entrants. The average time to complete the course was 10 hours and 21 minutes while the winning time was 9 hours and 15 minutes.

Demographics

The sample ranged in age from 23 to 53 years ($\underline{M}$ = 35.59 $\pm$ 7.89 years), ranged in weight from 130 to 192 pounds ($\underline{M}$ = 156.15 $\pm$ 15.08 pounds), and height ranged from 63 to 75 inches ($\underline{M}$ = 70.36 $\pm$ 2.67 inches). Additional demographic characteristics included: years of running ($\underline{M}$ = 8.30 $\pm$ 5.26 years); longest race run ($\underline{M}$ = 78.19 $\pm$ 68.43 miles); weeks trained for the race ($\underline{M}$ = 10.21 $\pm$ 8.70 weeks); miles per week trained ($\underline{M}$ = 59.26 $\pm$ 21.90 miles); average training pace ($\underline{M}$ = 7:54 $\pm$ 0:41 min:sec/mile); and predicted finish time ($\underline{M}$ = 9:41 $\pm$ 1:18 hours:min). The data presented includes the two female subjects except where otherwise indicated. Fifty-seven responses of the 61 entrants were obtained with respect to occupation. Eighty-four percent held white-collar or professional job positions, 7.6 percent held blue-collar or labor positions, and 7.6 percent were students. All subjects were white and non-smokers.

Subjects were divided into two groups post hoc. Survivors (n=18), were subjects who completed the race, while casualties (n=26), were subjects who either voluntarily withdrew or were

administratively or medically removed from the race for safety reasons. Significant differences existed between survivors and casualties for mean body weight $\underline{t}$ = (35) 2.73, $\underline{p} < .01$, predicted race time $\underline{t}$ = (35) 2.13, $\underline{p} < .05$, and average training pace $\underline{t}$ = (34) 2.15, $\underline{p} < .05$. The average values for these three measures were significantly lower for the survivor group. The two females were omitted from the analysis with respect to weight and height because of the distinct morophological differences between the sexes. The two groups significantly differed with respect to previous race experience, χ^2 = (7) 11.20, $\underline{p} < .05$, indicating runners with less race experience had a greater representation in the casualty group as presented in Table 1. It is noteworthy that of the seven runners who had never completed an ultramarathon prior to this race, only one finished. While prior race experience appears to be important, nine individuals with ten or more previous ultramarathons to their credit became casualties.

The most frequently stated goal reported by subjects (n=14) was to "finish the race" followed by the goal to "run a specific time" (N=13). The mean goal time was 10 hours and 2 minutes, with a range from 9 to 12 hours. Ten runners cited a specific finish place they wished to obtain. Finally, four individuals expressed a number of goals that were more subjective in nature than finishing for a certain time or place. These goals were to "run my best effort", "enjoy the run and make social contacts", "train for the Old Dominion 100-miler" and "to not get hurt."

TABLE 1

RELATIONSHIP BETWEEN ULTRAMARATHON PAST EXPERIENCE AND RACE COMPLETION

NUMBER OF PAST RACES	SURVIVOR		CASUALTY		TOTAL	
	N	%	N	%	N	%
None	1	2.5	6	15.4	7	17.9
1 to 5	6	15.4	5	12.8	11	28.2
6 to 10	4	10.3	1	2.5	5	12.8
More than 10	7	17.9	9	23.1	16	41.0

$\chi^2 = 11.20 \quad p < .05$

Psychological Measures

Pre and post-run means, standard deviations, and ranges for the six mood factors are reported in Table 2. Figures 1 and 2 are graphic presentations of differences between survivors and casualties for the POMS pre and post-run states respectively. The present sample of ultramarathoners exhibit an iceberg profile of mood states previously reported in elite athletes (Morgan, 1985). Figure 3 illustrates a comparison of the ultramarathoners to elite distance runners (Morgan and Pollock, 1977) with both samples exhibiting similar iceberg profiles characterized by scoring below the norm on negative psychological constructs, but above the norm for the one positively anchored vigor construct (Morgan and Pollock, 1977). Multivariate analysis was used to assess the main effects of the two levels of group and administration, namely casualty/survivor and pre-run/post-run, on mood state and subjective symptomatology. Only subjects having complete data for the POMS or the ESQ were included in the analysis.

The POMS scores revealed a significant multivariate main effect for group, F (1,28) = 2.94, $p < .05$, and for administration, F (1,28) = 19.44, $p < .001$. There was no significant interaction. Since the multivariate results for the main effects were statistically significant, univariate tests were conducted. Univariate results of the main effect for group revealed significant differences between casualty and survivor mood for fatigue, F (1,33) = 11.00, $p < .01$, with survivors reporting a greater degree of

TABLE 2

MEANS AND STANDARD DEVIATIONS BETWEEN SURVIVORS AND CASUALTIES OF DEMOGRAPHIC CHARACTERISTICS AND LEVEL OF SIGNIFICANT DIFFERENCE.

CHARACTERISTIC	SURVIVORS MEAN±S.D. (N)	CASUALITIES MEAN±S.D.(N)	T (DF)	SIG.
Age (yrs.)	35.24± 8.97 (17)	36.10± 7.38 (20)	.32 (35)	NS
Height (inches)	69.88± 2.15 (17)	71.30± 2.41 (20)	1.87 (35)	NS
Weight (lbs.)	151.24±10.79 (17)	162.95±14.65 (20)	2.73 (35)	.01
Years Running	9.32± 5.76 (17)	7.58± 4.96 (20)	.99 (35)	NS
Longest Race Run (miles)	96.96±83.54 (17)	65.94±53.42 (20)	1.37 (35)	NS
Predicted Race Time (hours:mins)	9:07± 0:55 (15)	9:56± 1:22 (20)	2.13 (33)	.04
Weeks Trained For Race	10.00± 6.20 (17)	10.10±10.82 (20)	.03 (35)	NS
Miles/Week Trained	62.47±20.78 (17)	58.33±23.96 (20)	.56 (35)	NS
Avg. Training Pace (min:sec/mile)	7:35± 0:42 (16)	8:03± 0:46 (20)	2.15 (34)	.04

FIGURE 1: PROFILE OF MOOD STATES

PRE RUN MOODS FOR SURVIVORS AND CASUALTIES

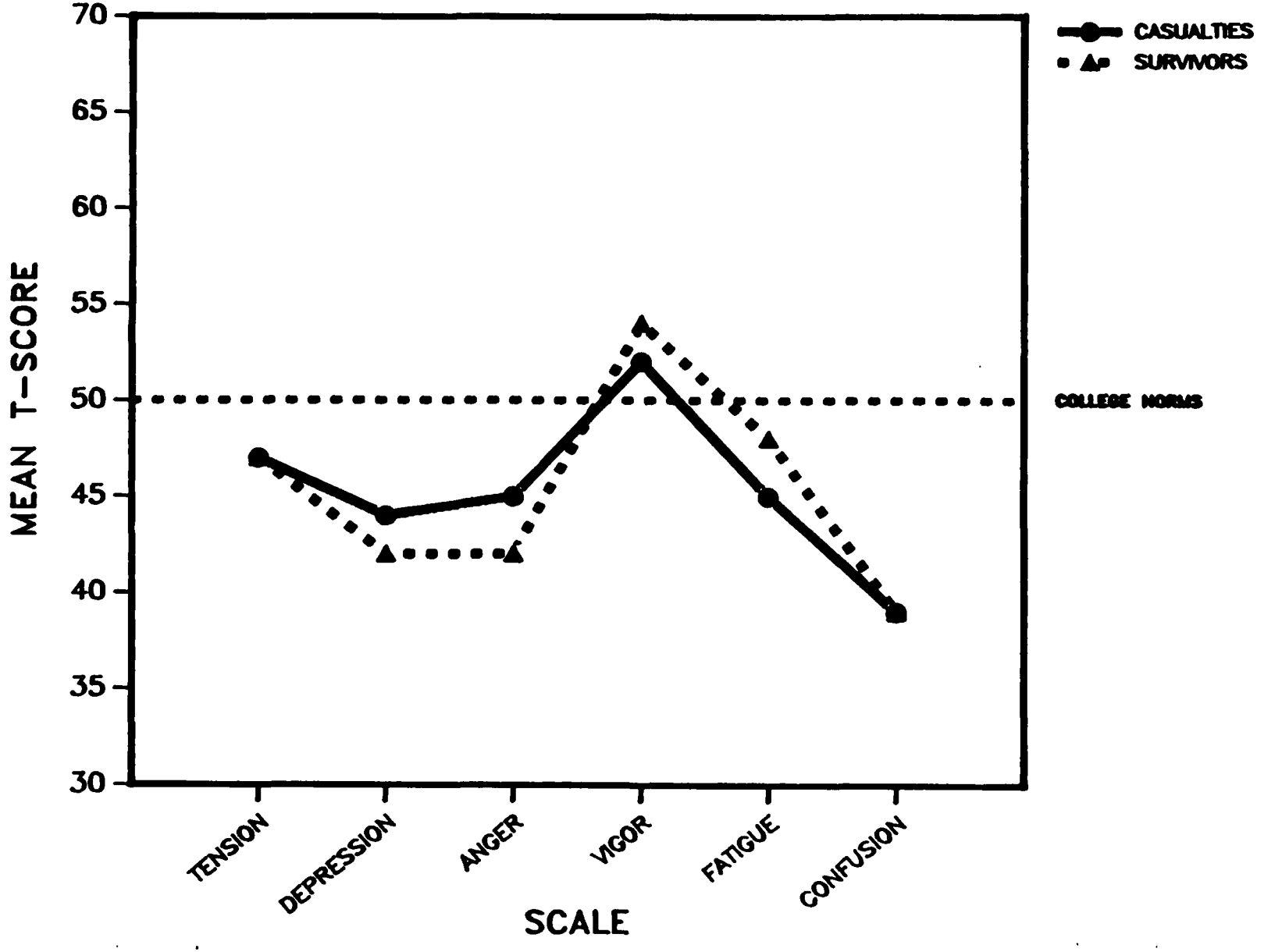


FIGURE 2: PROFILE OF MOOD STATES

POST RUN MOODS FOR SURVIVORS AND CASUALTIES

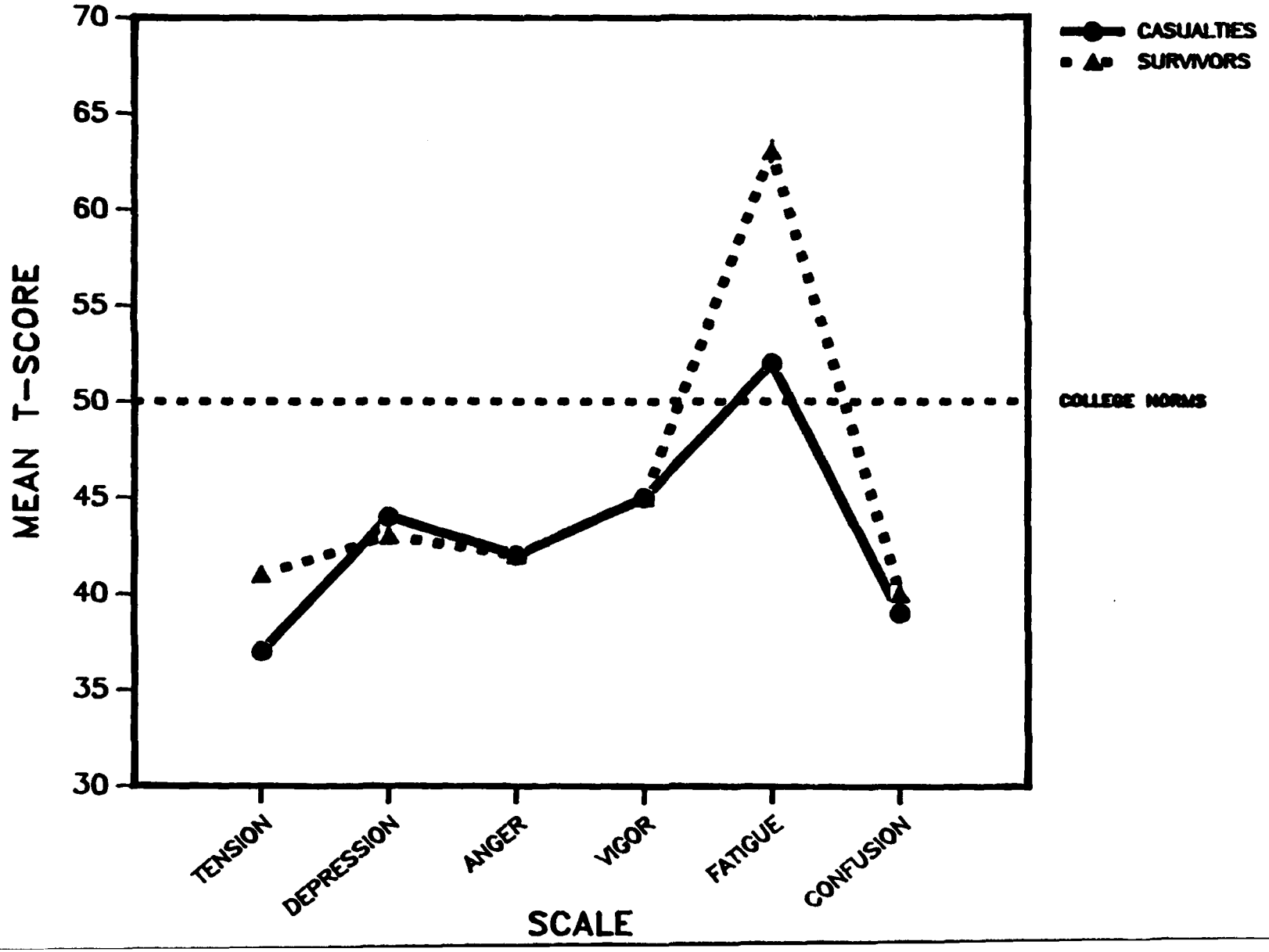
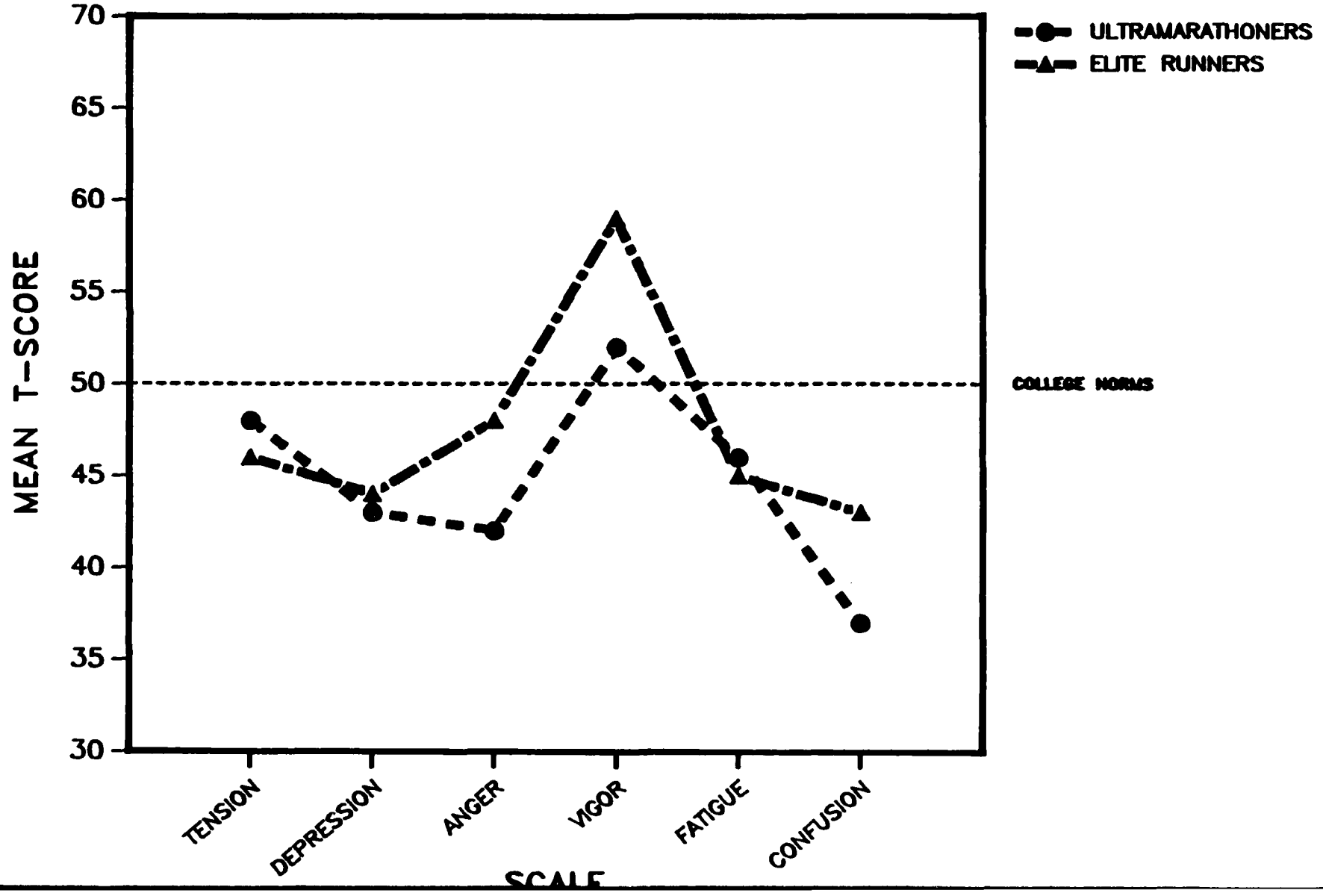


FIGURE 3: PROFILE OF MOOD STATES

COMPARISON OF ULTRAMARATHONERS AND ELITE RUNNERS



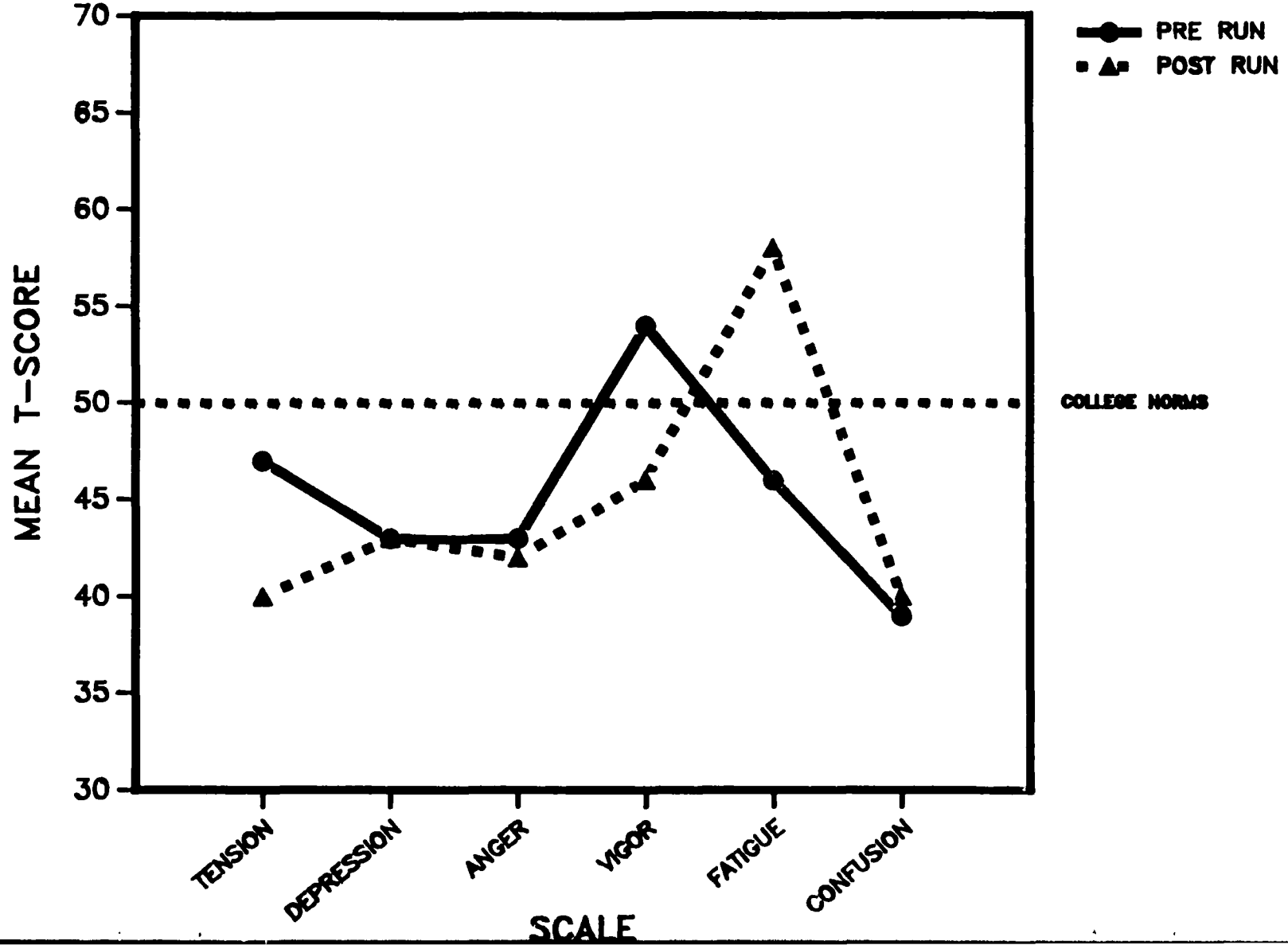
fatigue compared to casualties. A closer examination revealed no significant difference between casualties and survivors on the pre-run test. Post-run values, however, indicate that survivors expressed a greater degree of fatigue than casualties via a Scheffe' post hoc test with a critical difference of 5.91 necessary and acheived (1,33) $p < .05$. The difference in post-run fatigue is undoubtdly because survivors ran greater distances. Univariate results of the main effect for administration revealed significant differences between pre and post-run mood states for tension, F (1,33) = 27.09, $p < .001$, vigor, F (1,33) = 16.37, $p < .001$, and fatigue, F (1,33) = 38.40, $p < .001$. As shown in Figure 4, tension and vigor were reduced, while fatigue was elevated post run.

Table 2 also presents means, standard deviations, and ranges for self-motivation and trait anxiety scores. The present sample of ultramarathoners reported self-motivation scores above those found in college norms. No significant differences existed between survivors (160.50 $\pm$ 21.29) and casualties (160.00 $\pm$ 16.42) for self-motivation. Additionally, there was no significant difference between survivors (34.24 $\pm$ 7.66) and casualties (35.55 $\pm$ 7.36) for trait anxiety.

Multivariate analysis of the ESQ scores revealed a significant main effect for group, F (1,26) = 3.31, $p < .05$, and administration, F (1,26) = 14.13, $p < .001$. There was no significant interaction. Univariate results of the main effect for group revealed that survivors expressed significantly greater symptom intensities for

FIGURE 4: PROFILE OF MOOD STATES

COMPARISON OF PRE AND POST RUN MOODS



muscle cramps, F (1,34) = 5.26, $p < .05$, coordination off, F (1,34) = 4.31, $p < .05$, and concentration off, F (1,34) = 4.91, $p < .05$. Univariate results of the main effect for administration revealed significant differences in symptom intensity for a wide array of symptoms (Table 3), however, most notable were muscles feel tight, F (1,34) = 49.74, $p < .001$, feel weak, F (1,34) = 44.53, $p < .001$, legs or feet ache, F (1,34) = 155.74, $p < .001$, and feel tired, F (1,34) = 46.48, $p < .001$. Table 3 reports summary statistics and univariate F-values for the main effect of administration. All symptoms except for "feeling good" increased in intensity from pre-run to post-run. Twenty-six of the symptoms showed a significant change. Each symptom score was behaviorally anchored with "0" indicating the absence of a symptom, "1" the presence of a symptom of slight intensity, "2" a symptom being somewhat intense, "3" moderate symptom intensity, "4" quite a bit of symptom intensity, and "5" extreme symptom intensity. Table 4 shows symptoms that were present (i.e., having a mean ≥ 1), before and after the run. Notably there were only two symptoms, both of which relate to fatigue, reported before the run. There were, however, a variety of symptoms most of which were dominated by feelings of muscular fatigue and muscular exhaustion present after the run.

A stepwise multiple regression analysis was performed to identify factors which best predict 50-mile ultramarathon finish time. Finish time was converted from hours to minutes for conducting the multiple regression. Two factors, training pace and

TABLE 3

SYMPTOM INTENSITY MEANS, STANDARD DEVIATIONS AND
LEVEL OF SIGNIFICANT DIFFERENCE FROM PRE TO POST-RUN

SYMPTOM	PRE-RUN MEAN± S.D.	POST-RUN MEAN±S.D.	F	SIG.
Short Of Breath	.11± .40	1.08±1.25	20.58	.001
Hard To Breathe	.05± .23	.58± .73	18.68	.001
Hurts To Breathe	.03± .17	.28± .51	10.04	.001
Muscle Cramps	.25± .69	1.64±1.51	36.85	.001
Muscle Feel Tight	.47± .84	2.64±1.64	49.74	.001
Feel Weak	.36± .64	2.03±1.38	44.53	.001
Legs or Feet Ache	.42± .69	3.39±1.42	155.74	.001
Hands, Arms, Shou. Ache	.11± .32	1.42±1.32	37.11	.001
Back Aches	.44±1.00	1.33±1.26	19.82	.001
Feel Lightheaded	.17± .61	.83±1.06	15.36	.01
Feel Dizzy	.08± .28	.38± .60	10.27	.01
Feel Faint	.06± .23	.33± .67	5.56	.05
Coordination Off	.03± .16	.97±1.00	34.61	.001
Nauseous	.05± .33	.78±1.35	11.89	.01
Gas Pressure	.83±1.21	.33± .83	6.60	.05
Feet Are Sweaty	.41± .77	1.19±1.51	8.32	.01
Parts Of Body Are Numb	.03± .17	.75±1.16	15.45	.001
Mouth Is Dry	.17± .45	1.03±1.13	23.82	.001
Lost Appetite	.44± .97	1.19±1.51	8.57	.01
Feel Sick	.17± .51	.69±1.14	13.15	.001
Thirsty	.61± .90	.61± .90	26.72	.001
Feel Tired	1.05±1.21	3.00±1.55	46.48	.001
Couldn't Sleep Well	.61±1.02	1.72±1.92	11.88	.01
Concentration Off	.39± .73	.89± .91	5.18	.05
Feel Good	3.11±1.45	2.44±1.30	4.99	.05

TABLE 4

RANK ORDER OF COMPLAINT EXPRESSED WITH A
SYMPTOM INTENSITY GREATER THAN 1.0 (OR A RATING OF SLIGHT)

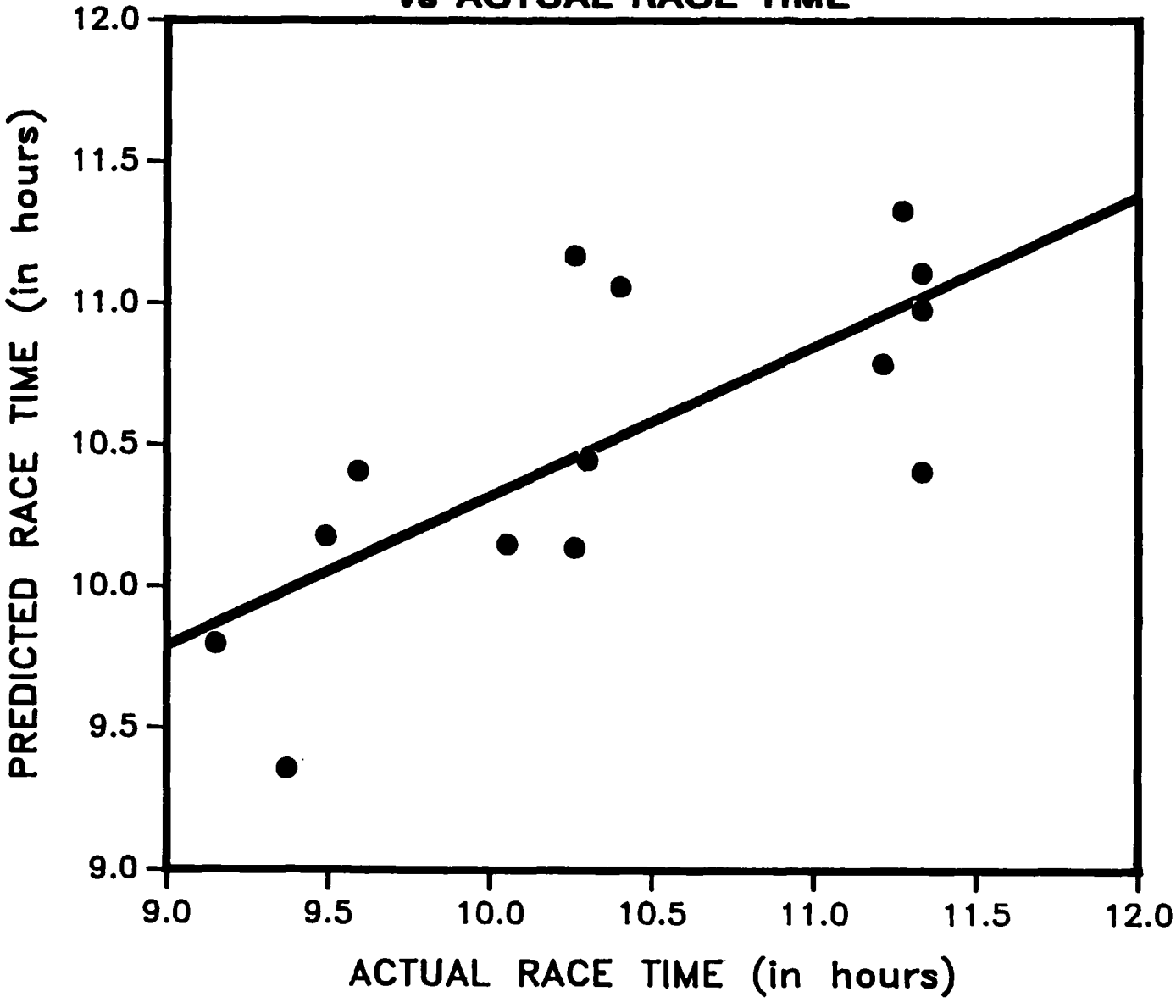
PRE-RACE	POST-RACE
1. Feeling Sleepy	1. Legs or Feet Ache
2. Feeling Tired	2. Feeling Tired
	3. Muscles Feel Tight
	4. Thirsty
	5. Couldn't Sleep Well
	6. Muscle Cramps
	7. Feeling Sleepy
	8. Hands, Arms or Shoulders Ache
	9. Sweating All Over
	10. Back Aches
	11. Feet Sweaty
	12. Lost Appetite
	13. Short of Breath
	14. Feel Warm
	15. Mouth is Dry

predicted finish time, were fairly successful in predicting final time (R^2 = .564, F (2,11) = 7.14, p < .01). All other variables failed to meet the entry criterion of the probability associated with F (p < .05). The coefficients for the final equation were (pace * 55.442 + predicted time * .379 + 4.253). Figure 5 illustrates the direction and strength (R = .75) of the relationship between actual race time and predicted race time for the 14 survivors who had complete data.

DISCUSSION

Several variables assisted in determining characteristics that best differentiate survivors from casualties. Ultramarathoners who finished the race (i.e., survivors) weighed less, ran faster in training, and aspired to run a faster time for this particular race in contrast to non-finishers (i.e.,casualties). One keynote that must be taken into account is that within the group classified post hoc as casualties were subjects who were medically pulled for saftey reasons. Medical pulls occurred when runners did not reach certain checkpoints in designated time periods. Since many runners were forced to run faster than they are capable of running or face being disqualified the results are skewed towards the faster runners being survivors. Not taken into account is the runner who is the slow, but steady performer, and given enough time would be able to complete the race.

FIGURE 5: REGRESSION OF PREDICTED RACE TIME vs ACTUAL RACE TIME



The means and standard deviations for background running information are consistent with those obtained in a previous studyon ultramarathoners (McCutcheon & Yoakum, 1983) and race summaries of the Old Dominion 100-Mile Endurance Run. Previous studies (McCutcheon & Yoakum, 1983 and Thompson et al., 1982) reported that fast ultramarathoners ran significantly more miles in training than did the slower runners. Folkins and Wieselberg-Bell (1981) reported no difference between ultramarathon finishers and non-finishers for age, years of running and miles per week trained. Significant differences were, however, found between finishers and non-finishers on the confidence-in-finishing scale (finishers scored higher) and finishers had run longer distances in previous races. The present results focused on survivor-casualty relationships and did not find a significant difference in training mileage, although, survivors were found to train at a significantly faster pace. The present findings also show that predicted finish time was significantly lower for survivors which corroborates the finding of Folkins and Wieselberg-Bell (1981) and possibly indicates that survivors had greater confidence in their ability. Moreover, the present findings indicate that previous ultramarathon experience does seem to be related to the ability to finish an ultramarathon.

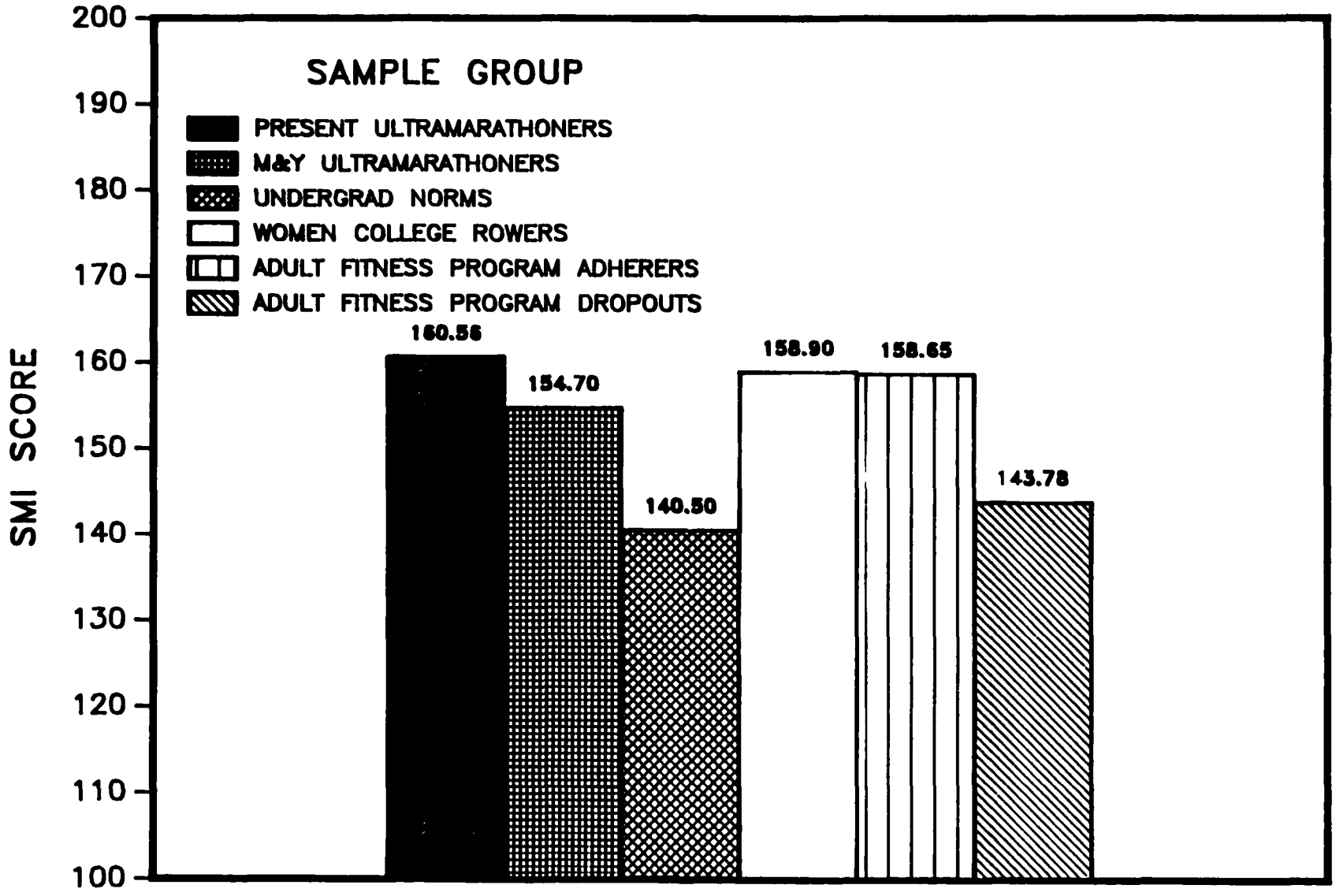
The goals for participation support the groupings Thompson et al. (1982) reported in a previous study of ultramarathoners. These groups ranged from extremely competitive individuals to the non-competitive/social runner. The majority of runners were found to be

most interested in improving their own performance either by running longer, faster or for a higher place than they have achieved in the past.

The measure of self-motivation used in the present study is a valid, internally consistent and reliable score when assessing individual motivation towards a training or exercise program (Dishman, et al. 1980). The present results indicate that the ultramarathoner's level of self-motivation was similar to the other athletic groups tested and higher than college norms (see Figure 6). The high self-motivation score may be indictive of the importance "running and training" has in the lives of these subjects. Previous research reported no significant differences in self-motivation scores between fast and slow runners (McCutcheon & Yoakum, 1983). The present findings indicate there were no significant differences in self-motivation between casualties and survivors.

The affective (mood) state of the present sample of ultramarathoners is similiar to elite athletes in middle-distance to marathon running, wrestling and crew (Morgan and Pollock, 1977 and Morgan, 1985) and psychometrically configure the iceberg profile previously reported by Morgan (1985). Affective variables from the POMS are traditionally reported and graphically presented in a sequential order of; tension, depression, anger, vigor, fatigue, and confusion (McNair, Lorr & Druppleman, 1981). Morgan (1985) further reported that since elite runners express vigor scores normally elevated far above college norms while the other five mood states

FIGURE 6: COMPARISON OF SELF-MOTIVATION INVENTORY SCORES



fall below; the graphic representation of this trend illustrates the shape of an iceberg. Previous findings on "average" marathon runners (Gondala & Tuckman, 1982) show iceberg profiles similar to the one found in elite athletes (Morgan, 1985) and the present study of ultramarathoners. Tension and vigor scores were significantly reduced while fatigue was significantly increased after completing the ultramarathon. The reduction in tension after the race supports the well established premise that acute exercise of vigorous intensities have been shown to reduce tension-anxiety (see review by Dishman, 1985).

Analysis of post-race symptomatology showed the most intense symptoms focused on muscular fatigue. In addition, complaints of heat related injuries were expressed with greater than slight intensity. These results are similar to findings from a 20 km distance race which reported prevalent symptoms of extreme fatigue, chills, and gooseflesh (Huges et al., 1985). Previous research has also shown that muscular fatigue and heat injuries are interrelated. When sweat loss approximates 6 to 10 percent of body weight, the resultant dehydration predisposes one to muscular cramping (Wyndham & Strydom, 1969). Other explanations for muscular soreness and cramping may be the length of time repeated muscular contractions are required and the eccentric muscular action that occurs in downhill running. The overall trauma from negotiating rugged, rocky, mountainous terrain may account for the relatively high intensity for backache. Knuttgen et al., (1982) reported a

relationship of downhill running and eccentric muscular action with perceived muscle soreness.

The results of the multiple regression confirm the finding of previous studies by Slovic (1977) and Mc Kelvie et. al. (1985) identifying training pace as a highly significant predictor of marathon finish time and for the present sample, ultramarathon finish time. It is worthy of note that we took a conservative approach in building the regression equation. Since our primary focus was on applying the equation to predict performance in ultramarathon population, the two constraints to building the model were the adjusted $\underline{R}^2$ and the standard error. Since the sample $\underline{R}^2$ tends to overestimate the population value of $\underline{R}^2$, adjusted $\underline{R}^2$ is a perferred measure of goodness of fit because it is not subject to the inflationary bias which occurs in an unadjusted $\underline{R}^2$ when numerous independent variables are added. Therefore, any factors which adversely affected the adjusted $\underline{R}^2$ and the standard error were eliminated.

It is important to identify moods and symptoms that predict success at finishing an ultramarathon or performance time since once identified, runners focus attention on those feelings or symptoms and avoid those that deter from successful performance. Morgan and Pollack (1977) found that elite distance runners avoided pain zones by monitoring sensory input and adjusting their pace. These associative techniques were used by elite athletes as opposed to disassociative ones (e.g. sing to oneself, daydreaming pleasant

fantasies, etc.), which were more predominant in the slower runners. By using associative techniques on those symptoms and moods that contribute to success one would expect better performances.

The findings of the present study are of significance to the U.S. Army in that comparisons between the ultramarathon and a sustained military operation show many similarities. Sustained military operations require physical exertion for a prolonged period of up to 72 hours. Recommendations made to the ultrarunning community are also relevant to the military. Learning to manage stress, utilizing the most advantgeous training techniques, and the employment of goal-setting strategies are important to enhance human performance.

The athlete and the solidier must appreciate the efficancy of cognition on physical performance. Contemporary training strategies must consider an interdisciplinary approach emphasizing both physiological and psychological parameters.

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